DOCUMENT RESUME

ED 224 479 IR 010 562

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TITLE Word Problem Solving with the Apple II.
PUB DATE 82
NOTE 13p.; Paper presented at the Florida Instructional Computing Conference (Orlando, FL, 1982).
PUB TYPE Reports - Descriptive (141) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; *Computer Programs; Elementary Secondary Education; *Instructional Materials; *Mathematics Instruction; *Microcomputers; *Problem Solving; Program Evaluation; Ratios (Mathematics)
IDENTIFIERS Apple II

ABSTRACT

The aim of this project was to develop computer programs that will provide training in the use of a strategy for solving word problems in everyday mathematics. The strategy includes (1) classifying the problem by type, according to problem characteristics such as symbols, diagrams, relevant formulas, and arithmetic operations; (2) identifying the unknown; (3) identifying the data, and the relationship between them; (4) constructing a representation of the situation; (5) identifying the conditions, if any; (6) carrying out the solution steps; and (7) checking the result. Seventeen modules were developed on such topics as simple interest, sales tax, discounts, measurement, area and perimeter, and comparison shopping. A recordkeeping program was also developed. The complete set of project materials includes the microcomputer programs in five diskettes (for use with the Apple II Plus microcomputer), a teacher's guide, and a student booklet. The program was designed for use by general mathematics students from grades 6 to 12 and adults. Eleven references are listed. (Author/LMM)

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WORD PROBLEM SOLVING WITH THE APPLE II

by

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WORD PROBLEM SOLVING WITH THE APPLE II

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The lack of word problem solving skills in basic mathematics is a widespread problem throughout the nation. In measuring math achievmeent of 17-year-olds and young adults between the ages of 26 and 35, the National Assessment of Educational Progress Newsletter (August, 1965) reported the following findings: (1) less than one-half of the 17-year-olds and adults could successfully determine the cost of the most economical size of a product; (2) only 10 percent of the 17-year-olds and 20 percent of the adults could correctly calculate a taxi fare; and (3) one percent of the 17-year-olds and 16 percent of the adults could balance a checkbook. In the August, 1976 issue of the National Assessment of the Educational Progress Newsletter, the consumer math assessment showed that performance was generally below the national average for people living in the Southeast, Blacks, people living in the inner city and people whose parents have little or no high school education.

In Florida, only sixty-four percent and seventy-four percent of the eleventh graders passed the mathematics section of the State Student Assessment Test (formerly called the Functional Literacy Test) in 1977 and 1978, respectively. The failure rates for blacks was seventy-five and sixty percent for the respective years. This was of particular concern at Florida A&M University, a predominantly black institution.

Investigators researching the possible causes of the problem provide evidence that it is not primarily a reading problem; students with the basic decoding skills for reading the printed word and students

with normal scores in reading comprehension were shown to experience difficulty in solving word problems. Possible causes for this difficulty were listed to be: (1) the inability to understand the problem, that is, the inability to make a meaningful description of the problem situation; (2) the inability to monitor progress toward a successful solution; and (3) the inability to carry out arithmetic operations correctly.

Drill and practice on computation skills can take care of the third problem. Regarding the first problem, Polya, the author of "How to Solve It" suggested training in the skills of abstracting the essential problem elements involving the following:

1. identifying the unknown,
2. identifying the data and the relationship between them,
3. constructing a representation of the situation, and
4. identifying special conditions, if any.

Identifying the unknown gives the student a sense of direction and a feeling for what is being asked in the problem. The other three problem elements enable him to formulate the symbolic relationships among the data, and a pictorial representation of these relationships.

The third problem--the inability to monitor progress toward a successful solution--is probably the most difficult skill to develop. This involves setting up solution steps including all of the problem elements and then testing the adequacy of the solution--Do all the elements fit together in a meaningful representation so that the unknown can be solved for correctly?

The literature does not have very much to provide in terms of specific strategies that teachers could possibly use to maximize the development of this skill other than a lot of practice in solving related word problems. There is, however, one important finding made by Hinsley,

Hayes, and Simon (1977) regarding processing strategies which they found their subjects to utilize when solving algebra word problems that could be worth incorporating into a strategy for word problem solving in math. The findings were:

1. Subjects recognize categories such as work, rate, river current, probability, etc.
2. Subjects have information about the problem categories which is useful for formulating problems for solution such as useful equations and diagrams and appropriate procedures for making relevance judgments.
3. Subjects can and often do use this information in solving algebra word problems.

On the basis of this information, the word problems in the Florida State Test were classified according to the unique characteristics of their problem solutions based on the relevant formulas, symbols, arithmetic operations and diagrams. See the first column of the table.

The first three skills are self-explanatory. The great majority of the skills fell under problems requiring ratio and proportion solutions. Percents and decimals are a special form of ratio and proportion. The measurement problems involve unit conversion and the process utilizes ratio and proportion. Area and perimeter problems utilize unique formulas and figural representations. Time problems are unique with the use of the clock and the calendar, and their solutions are complicated by the conversion of days to hours and hours to minutes, and vice versa, and by elapsed time including 12:00 noon or 12:00 midnight. Comparison shopping involves multiplication and/or division and comparison of costs of unit items or sets of items.

It is interesting to note that when these skills were arranged according to relative difficulty based on the percentage of students passing

SKILLS IN THE FLORIDA STATE STUDENT ASSESSMENT TEST, PART II
CLASSIFIED BY TYPE

Skills	Percentage of Students Passing			
	1977	1978	1979	Mean
Currency	96%	99%	99%	98%
Graphs	94%	94%	97%	95%
Whole Number Operations	84%	87%	88%	86%
Ratio and Proportion:				
Percents and Decimals	82%	81%	83%	82%
Simple Interest	53%	84%	83%	82%
Rate of Discount	74%	80%	79%	78%
Purchase and Sales Tax	76%	84%	87%	82%
Rate of Discount (Fractions)	74%	80%	79%	87%
Unit Conversion:				
Distance Measurement	69%	75%	76%	73%
Capacity Measurement	70%	53%	77%	67%
Mass/Weight Measurement	47%	68%	45%	53%
Area & Perimeter	47%	35%	60%	48%
Time: Clock	36%	39%	70%	48%
Calendar				
Comaparison Shopping	43%	50%	47%	47%

the skills statewide, the arrangement reflected this classification. Those skills involving ratio and proportion were found in a cluster with those requiring unit conversion appearing at a slightly more difficult level than those requiring percents, decimals and fractions.

On the premise that it might be possible to maximize the development of the problem solving skill by training students to classify problems by type according to the cues within the problem, this project attempted to develop a style of attack appropriate to each skill by showing the students how to classify the problems by type and showing them worked-out examples.

There was the use of consistent heuristics for each type. Then, practice was given in solving different types of problems in response to the intrinsic problem characteristics.

The complete strategy for solving word problems that was used in this project consisted of:

1. classifying the problem by type,
2. identifying the unknown,
3. identifying the data, and the relationship between them,
4. constructing a representation of the situation,
5. identifying special conditions, if any,
6. carrying out the solution steps, and
7. checking the result.

The microcomputer was chosen to deliver the training because (1) it allows students to proceed at their own rate, (2) it is not threatening and it is a patient teacher, (3) it can give immediate feedback at each step along the way, and (4) a record-keeping system can be built-in to inform the student and the teacher how the student has performed.

The following seventeen modules and a record-keeping system were developed:

A. Arithmetic Operations
B. Ratio and Proportion
C. Unit Conversion
D. Distance Measurement
E. Capacity Measurement
F. Weight Measurement
G. Percents
H. Simple Interest
I. Sales Tax
J. Fractions & Discounts
K. Percents & Discounts
L. Area & Perimeter
M. Elapsed Time
N. Ending Time
O. Clock Time
P. Calendar Time
Q. Comparison Shopping

The student takes a short quiz before proceeding through certain modules to determine whether or not he has the necessary computational skills to proceed. At the beginning of each module, the student is presented

with the classification type for the problem followed by a short introduction that is limited only to necessary information. Graphics and a little music here and there are utilized for attention getters. The student is guided through a number of representative examples of items while training him to identify the problem elements. By way of illustration, consider the following problem: "Mary prepared 5 quarts of punch for the party. How many cups can she serve? (4 cups = 1 quart)"

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**********************************************************
      STEP 1.  WHICH IS THE PROBLEM STATEMENT?
      1. HOW MANY QUARTS OF PUNCH DID MARY PREPARE?
      2. HOW MANY CUPS CAN SHE FILL UP?
      3. HOW MANY CUPS ARE IN 1 QUART?
      4. HOW MANY CUPS ARE IN 5 QUARTS?
      TYPE THE NUMBER OF YOUR ANSWER:
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For every question in the practice problems, the student is allowed 2 chances to answer the question correctly. When the correct answer is given, a bell rings 5 times and the computer prints, "Wow! That's correct.", "Fantastic!" etc. The first time the student gives a wrong answer, the computer says "uh-huh" and prints "Try again". If, on the second try, the student gives a wrong answer, the computer again says, "Uh-huh" and prints and correct answer.

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**********************************************************
      STEP 2.  WHAT ARE THE DATA?
      HOW MANY QUARTS OF PUNCH DID MARY PREPARE:
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In step 2, the student identifies all of the given data, one at a time.

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STEP 2. WHAT ARE THE DATA?

THE NUMBER OF CUPS IN 1 QUART IS:

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In step 3, the student identifies the special conditions if there are any. There are no special conditions in this problem. However, in a problem from the Time module-- "Jim worked from 7:30 A.M. until 5:00 P.M. How long did Jim work in hours and minutes if he took 45 minutes off for lunch?" --the special condition is that Jim took 45 minutes off for lunch.

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STEP 3. ARE THERE ANY SPECIAL CONDITIONS?

TYPE YES OR NO:

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The student is presented with the solution steps in step 4 and then asked to solve for the answer using the steps given.

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STEP 4. WHAT IS THE SOLUTION?

FIND HOW MANY CUPS OF PUNCH ARE IN 5 QUARTS
USING RATIO AND PROPORTION.

SOLVE FOR THE ANSWER.

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The student enters his answer in step 5. If the answer is correct, a happy person jumping up and down appears on the screen. Otherwise, a sad face with tears rolling down his cheeks appears on the screen. It is

interesting that the students do not like the sad face and will try to avoid it as much as they can.

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STEP 5. WHAT IS THE ANSWER?

HOW MANY CUPS OF PUNCH ARE IN 5 QUARTS:

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The last step is "Let Us Check Your Answer." The computer presents the solution step(s) in the formula form but the student is expected to supply the answer. The information in this frame is printed on the screen at a slower rate, approximately 1 to 2 words per second, so the student will read what's being printed on the screen at a slower rate and hopefully will take time to study the solution.

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STEP 6. LET US CHECK YOUR ANSWER.

$$\frac{4 \text{ CUPS}}{1 \text{ QUART}} = \frac{? \text{ CUPS}}{5 \text{ QUARTS}}$$

$$4 \text{ CUPS} \times 5 \text{ QUARTS} = ? \text{ CUPS} \times 1 \text{ QUART}$$

$$? \text{ CUPS} = \frac{4 \text{ CUPS} \times 5 \text{ QUARTS}}{1 \text{ QUART}}$$

THE NUMBER OF CUPS IS:

****

After going through a series of representative examples like these, the student works on 10 or more problems on his own. He is allowed as much time as he needs to solve a problem but every 2½ minutes he hears the music to "Are You Sleeping?". That gives him the gigles when he needs it. The computer keeps track of the student's score. If the student fails to meet the standard of 80% of the number of items, he is directed to go over the module.

If he passes, he proceeds to the next module or he takes a level quiz if there is one. A level quiz consists of word problems from the different modules that he has successfully completed. In this quiz, he is not only asked to solve the problem but also to classify the problem by type.

If he passes the level quiz, he proceeds to the next module. If not, the student will have to make up for his deficiencies to be decided by the teacher depending upon the extent of his deficiencies.

The project materials were field-tested with the General Math students at the Florida A&M University Laboratory School. Results were:

1. The problem solving skills increased substantially for the majority of the students. The overall mean increased 32% as measured by the evaluation test.

2. The microcomputers were found to be very effective tutors. They freed the teacher of the task of keeping up with the better students. She was able to devote most of her time to helping slower students in interpreting some of the word problems.

3. The students enjoyed learning with the materials. They would cut short their lunch period so they can start working on the microcomputer earlier.

4. The materials were designed such that students monitored their progress through the materials. Students stayed on task most of the time at the school's Learning Research Center.

5. The average students completed the modules in 20 class meetings or less; the below average students (those scoring at the stanine 1-3 in an IQ test), in approximately 32 meetings.

However significant the results were, like any skill, the experience must be followed through with extension activities for intermittent reinforcement especially for the slower students. They needed a lot more practice in solving 2-step problems than is provided in this project.

The project materials also comes with a management system called the "Student Record Files". This enables the teacher to store and update information for each of the students in a class as they go through the project materials.

The complete set of project materials consists of the computer programs in 5 diskettes, a Teacher's Guide and the Student Booklet. For further inquiries, please contact the research coordinator at the FAMU Laboratory School, Box A-19, Florida A&M University, Tallahassee, Florida 32307.

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